NATIONAL BUREAU OF STANDARDS May/1967

Technical News Bulletin

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

TNB Technical News Bulletin

MAY 1967/VOL. 51, NO. 5/ISSUED MONTHLY

U.S. DEPARTMENT OF COMMERCE
Alexander B. Trowbridge
Acting Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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The frequency range of vibrators for calibrating accelerometers has been extended by development of a vibrator incorporating a lightweight ceramic armature and an air-bearing suspension. T. Dimoff inserts the ceramic armature into the vibrator. *(See page 90.)*

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized into three institutes—

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

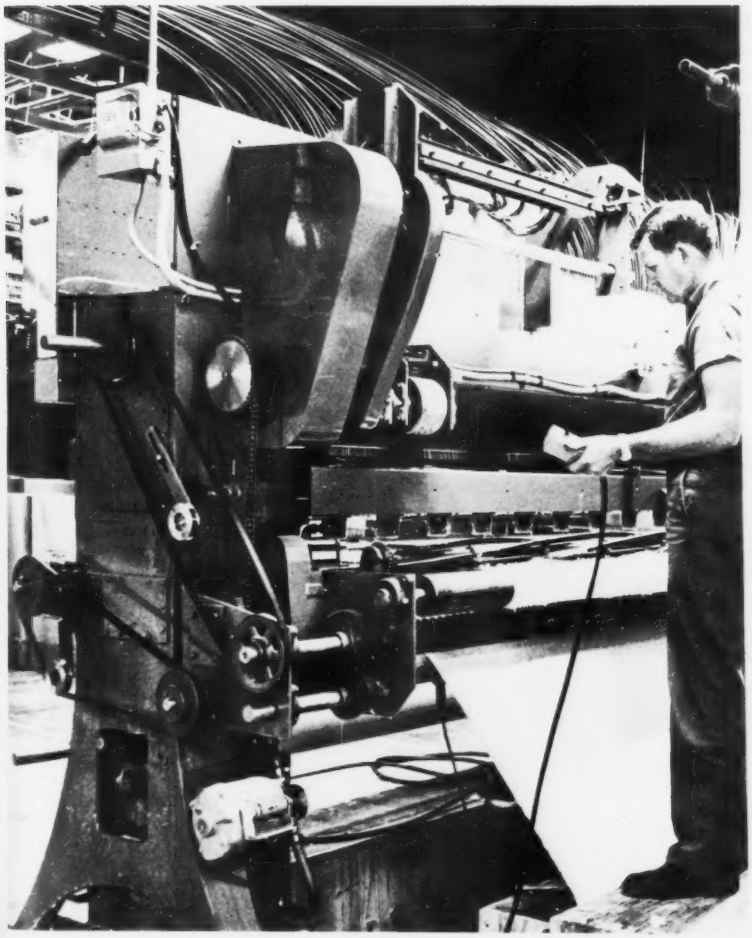
The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Subscription price: Domestic, $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 19, 1961).

Library of Congress Catalog Card Number: 25–26527

NBS Develops Computerized Industry Model

Operation of Tufted Carpet Mill Simulated



Much carpeting is made by inserting tufts of yarn into a textile base, as shown here; later a layer of adhesive will secure the tufts and a backing layer. (Photo courtesy of The Tufted Textile Manufacturers Assoc.)

The tufted carpet industry has been simulated by a mathematical model developed by Gary C. McKay and Jerome Yurow, of the NBS Institute for Applied Technology, in cooperation with the Tufted Textile Manufacturers Association and with the contract assistance of Management Science, Atlanta. The model has as variables the policies used by retailers, wholesalers, manufacturers, and yarn suppliers to maintain inventories. It enables operational policies to be altered by the experimenters and the consequent behavior of a typical business in the industry to be studied. The model simulates the flow of goods in the industry; operating the model with reduced inventories, for example, demonstrated that such a basis may be practicable for sectors of the industry. Although the model simulates the tufted carpet industry, its primary purpose was to demonstrate the usefulness of the technique for other industries as well.

Simulation

Simulation—representing an action or object by other than its actual size, materials, or relationships—has become increasingly useful to scientists. It enables pilots to be trained without leaving the ground, materials to be tested for response to exotic environments (the jungle, the moon, or in a corrosive atmosphere), and the handling and seaworthiness of ships to be determined while still on the drawing board.

Computer manipulation of mathematical models offers an effective way of simulating the operation of systems which can be described numerically. The Institute's Technical Analysis Division uses such models in much of its work. In the present case

INDUSTRIAL MODEL *continued*

it sought to demonstrate how such a model can simulate an industry composed of consumer, retailer, wholesaler, manufacturer, and supplier of raw materials.

Model of an Industry

To set up the model of the tufted carpet industry, the Bureau study group got information on details of industry operation by visiting plants and asking a series of questions at each. The investigators decided to represent the industry by "sectors": the retailer serving the consumer, a wholesaler in some cases, a carpet tufting and finishing manufacturer, and a yarn supplier. The individual businesses in each of these sectors were found to maintain similar inventories and to use similar ordering and stocking policies. The collective consumer sets the demand for the entire industry, each unit of which attempts to maintain fixed inventory during all ups and downs of business.

Manufacturing Carpeting

Tufted carpets are made by banks of needles which thrust loops of yarn through jute fabric, the back of which is then coated with adhesive and covered with layers forming the base of the carpet. More than half of the industry's output is made as greige (gray, or uncolored) carpeting in several widths which are kept in stock to be "piece-dyed" in any color needed.

A smaller proportion of the output is "stock-dyed"—made from colored yarn. A typical mill produces carpets by both methods in 2 or 3 widths, 5 to 10 patterns (formed by variation in pile density and thickness), and 10 to 20 colors. The tufting mill is treated in the model as producing four lines of carpeting: greige carpeting for inventory, greige carpeting for special order, stock-dyed carpeting for inventory, and stock-dyed carpeting for special order.

Finishing consists of attaching the backing, dyeing the carpeting, and forming carpets by shearing, edging, and cutting. Finishing operations are sometimes performed under the same roof as the tufting, but the finishing sector maintains its own workflow and inventory like a separate concern. However, the total tufting production of a tufting and finishing factory can typically be finished within the factory without creating a pileup of unfinished carpeting, so the two areas were consolidated in the study.

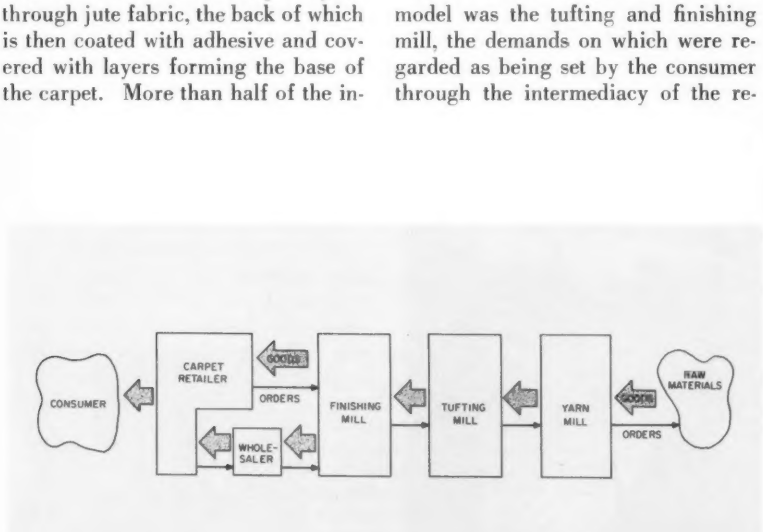
The most detailed sector of the model was the tufting and finishing mill, the demands on which were regarded as being set by the consumer through the intermediacy of the retailer and wholesaler. Labor was regarded as fixed in cost, but the effect of labor practices with respect to abrupt changes in the workweek were included in the model. The mill was assumed to have fixed productive capacity, unrestricted by yarn supply, transportation, storage, or finishing capacity.

Validation of Model

The model was validated by operating and adjusting it until it behaved in the same way that the real industry behaved under similar circumstances. On finding the model to be stable for a fixed input—product demand—the study group subjected it to five types of demand variation, superimposed on a static demand of 90,000 square yards per week. These were: a step input, ramp growth (steadily growing demand), pulse input (simulating first-of-the-week backlog), cyclic input (representing seasonal variations), and random "noise" (representing small normal fluctuations). The model reacted to each demand variation by compensating for the change and then seeking to return to the static level—behavior like that of the industry it simulated.

Operation of Model

The operation of a concern in any sector of the industry is greatly influenced by its inventory adjustment policy. Too slow a response to changed demand could result in some items being overstocked and others out of stock, while too rapid a response would result in a more stable inventory at greater production cost. In the model each sector was started with an inventory sufficient for two weeks of normal operation and replenished by orders requiring two weeks for delivery. The inventory levels of the



Operation of the tufted carpet industry is described by a model in which goods flow through various mills to retailers. A reverse flow of orders governed by the model maintains inventories in each sector at the levels actually found in the industry.

model showed some fluctuation and then stabilized at the starting level, much as do the originals of the model.

Stability of levels of inventory, unfilled orders, machine-hours of mill operation, and production in the model were measured to evaluate the response to changes in desired inventory level and the effects of variations in policy. Seven different policies were tested; stability was obtained with use of the two-week practice and, with special treatment for reordered carpeting and unfilled orders, a one-week policy. The other policies tested were found to be patently unsatisfactory.

Also of interest to the industry are findings concerning the dependence of the inventory level on variety of items stocked. Specifically, how much would the inventory for each item have to be increased to enable filling the same percentage of orders if the number of items offered is reduced? Or, with increased variety how much can the inventory per item be reduced? The qualitative relationship is already well understood by industry; models can add quantitative information.

Analysis of operation of the tufted carpet industry model suggests areas for further study; these include expansion of manufacturing capacity, consumer-industry interaction, and merchandising and credit. Future study of the mill-wholesaler-retailer relationship, particularly in regard to ordering, inventories, and transportation, should be useful to the industry. Most important, executives and administrators should see in the simulation model a tool that could be useful for other industries also.

Ad Hoc Cryogenic Committee Formed

In recent years practical applications involving cryogenic fluids and cryogenic techniques have expanded greatly, both in volume and variety, creating a need for accurate cryogenic flow measurements and standards.

In recognition of this need, an Ad Hoc Committee, established under the cognizance of the Technical Department of the Instrument Society of America, met at the NBS Cryogenic Laboratory, Boulder, Colo., on January 16 and 17, to define the broad national requirements for cryogenic fluid flow measurements and standards.

To properly define national needs, the Committee is examining cryogenic application areas where flow measurements are made for diagnostic, control, or custody transfer purposes; such areas include: frozen foods, steel manufacture, missiles and rockets (aerospace), liquefied natural gas, medicine and biology, universities and research installations, and cryogen production and resale.

The Committee will investigate the economic justification for a national cryogenic facility in terms of national needs. It will also consider establishing a position and a method of implementation by which the ISA Headquarters and ISA members can support and promote the recommendations and findings of the Committee. As the Committee discusses these problems, it will prepare recommendations for solutions of specific problems which will be compiled as a report.

Because of the broad scope of cryogenic applications and the variety of measurement interests, the Committee is composed of members representing those interests. K. D. Timmerhaus, Associate Dean of Engineering at the University of Colorado and Editor of "Advances in Cryogenic Engineering," is Chairman of the Committee; he represents universities and research installations. Other Committee members are: W. J. Alspach of NBS (representing the U.S. Government); A. E. Schuler of NASA and R. L. Galley of Douglas Aircraft (both representing aerospace interests); L. N. Mortenson of Wyle Laboratories (commercial test and calibration laboratories); M. H. November of Potter Aeronautical and T. Lowler of Cox Instruments (both representing flowmeter manufacturers); W. W. Cofield of Transcontinental Gas Pipeline Co. (natural gas industries); G. C. Nubel of Air Reduction Co. (cryogen producers); and W. S. Watson of the California Bureau of Weights and Measures (state regulatory agencies).

To achieve its goals, the Committee members plan to meet several times before June 1, 1967, at which time a Committee report will be presented at the ISA President's spring meeting.

Additional information on Committee actions may be obtained from Mr. W. J. Alspach, National Bureau of Standards, Boulder, Colo. 80302.

Frequency Range of Calibration Vibrators Extended

Ceramic Armature and Air Bearings Improve Performance

"Shakers," vibrators for calibrating accelerometers, have been substantially improved at the NBS Institute for Basic Standards since 1960. NBS research and development,* especially by Todor Dimoff, Earle Jones, B. F. Payne, and D. R. Bryant, have considerably extended the usable frequency range and reduced the transverse motion of shakers.

Recently Mr. Dimoff advanced shaker design by using a piezoelectric accelerometer in place of the shaker's velocity coil and by using a permanent magnet to provide the field.[1] The redesigned moving element was made of ceramic material, further reducing its mass, improving its stiffness, and simplifying its design. The higher resonance frequency of this moving element extends shaker operation to 5000 Hz. The new suspension system, which incorporates air bearings, reduces undesired transverse motion and makes it easy to remove and exchange shaker armatures.[2]

Vibrators

Accelerometers and vibration transducers are calibrated at NBS by measuring their electrical output while they are being shaken by a vibrator at a known frequency and amplitude. A typical shaker consists of a long, vertically mounted armature carrying a drive coil near its lower end and, below the mounting table on its upper end, a velocity-sensing coil. The armature is usually supported by flexure plates at both ends, which allow it to move up and down with restricted transverse motion.

The ratio of transverse-to-longitudinal motion had previously been improved at NBS with the use of air bearings adapted to this application by Dimoff and Payne. Enough transverse motion remained, however, to justify continued research and redesign efforts. In addition, the several components (shaft, table, velocity coil and bobbin, and the driving coil and its mounting studs and supporting ring) and the different materials of the armature produced troublesome resonances. These problems led to a change in the approach to shaker design, resulting in improvement of the ratio of transverse-to-axial motion, extension of useful operating frequency, and simplification of use.

Design Approach

Part of the great length and mass of the conventional shaker armature was necessary to separate the shaker drive magnetic field from the velocity-sensing field. Use of the permanent drive magnet and a piezoelectric accelerometer, which is unaffected by magnetism, for determining shaker excursion eliminated any need for separation. Several components—a d–c power supply and the velocity-sensing magnet—also were eliminated with resultant cooler operation and improved characteristics of the magnetic field.

The conventional moving element can be considered to be two masses (one at the velocity coil end and the other at the driving coil end) connected by a shaft which unavoidably has some springiness. The low resonance frequency of this arrangement imposed a low upper limit on the frequencies at which such a shaker could be used. Shortening the shaft increased the resonance frequency by reducing both the armature's mass and its springiness.

An alumina ceramic was selected as the material for the new moving element. Although slightly more dense than the aluminum previously used, it offered a better modulus of elasticity (is a stiffer "spring") than aluminum and is dimensionally more stable, having a lower coefficient of thermal expansion than either aluminum or steel. Being an electrical insulator, it blocks eddy currents and can be fabricated in ways to eliminate some parts. For example, the driving coil is wound directly on the armature, eliminating the resonances of a coil form, mounting parts, and insulators. Elimination of these parts also reduced mass, further raising the upper frequency limit of operation.[3]

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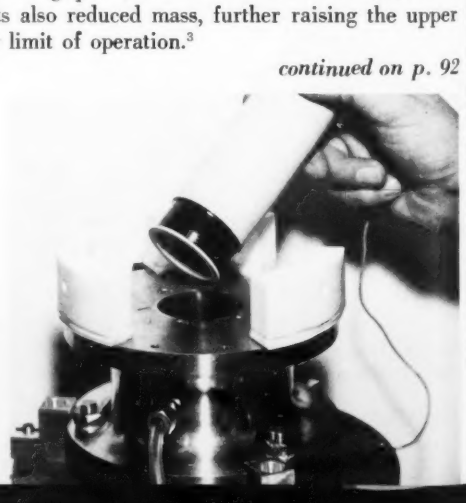
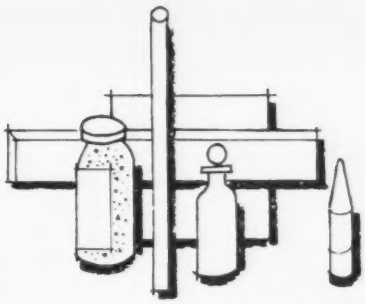


The ceramic armature being inserted into a shaker air bearing has greatly improved shaker performance because of its stiffness, lightness, and elimination of parts. The driving coil is wound at the lower end of the armature, the reference accelerometer is inside, and the pickup to be tested will be mounted at the top.

STANDARD REFERENCE MATERIALS



The NBS Office of Standard Reference Materials has recently issued three new and two renewal standards.[1] One of the new standards—a zinc freezing point standard—can be used as a fixed point on the International Practical Temperature Scale. The others are cobalt-60 radioactivity standards.

Zinc Freezing Point Standard

In 1960 the General Conference on Weights and Measures placed the freezing point of zinc on a par with the boiling point of sulfur as a fixed point of the International Practical Temperature Scale (IPTS). This was stated in a footnote to Table 1 of the 1960 text revision of the 1948 IPTS, as follows:

> In place of the sulfur point, it is recommended to use the temperature of equilibrium between solid zinc and liquid zinc (zinc point) with the value 419.505 °C (Int. 1948). The zinc point is more reproducible than the sulfur point and the value which is assigned to it has been so chosen that its use leads to the same values of temperature on the International Practical Temperature Scale as does the sulfur point.[2]

The zinc point is eventually expected to replace the sulfur point on the IPTS. Such an action will be an important step forward in the maintenance of the temperature scale, and it will require the international availability of well characterized, high-purity zinc standards.

The National Bureau of Standards has therefore undertaken the task of preparing a zinc freezing point standard that will meet all of the requirements of a fixed point on the International Practical Temperature Scale. This standard is now available as NBS Standard No. 740, Zinc.

NBS No. 740 is a solid piece of zinc metal cut from a cylinder 2 inches long and 2 inches in diameter. The standard weighs 350 grams and has a purity of 99.9999 percent. It costs $65 per unit.

The material for this standard was supplied by the Cominco American Corporation, Spokane, Washington. Evaluations for purity and homogeneity were made in the NBS Institute for Materials Research by Robert Powell of the Cryogenic Properties and Solids Section, and by Robert Alvarez and Paul Paulson of the Spectrochemical Section. Temperature studies were performed on the material by John P. Evans of the Temperature Section, NBS Institute for Basic Standards.

New Radioactivity Standards

Two new radioactivity standards of cobalt-60 have recently been prepared, certified, and made available for purchase. Cobalt-60, with a half life of 5.27 years, transforms by beta decay into nickel-60 which then emits 1.33-MeV and 1.17-MeV gamma rays in cascade.

The new standards are NBS Standard Nos. 4203–A and 4203–B, which consist of the radionuclide deposited, as the chloride, on polyester tape 0.006-cm thick and covered by another layer of the same tape, cost $65 per unit.

NBS No. 4203–A has a disintegration rate of approximately 3×10^5 per second as of August 1966. It may be ordered singly under the general licensing provisions of the Atomic Energy Act of 1954.

NBS No. 4203–B has a disintegration rate of approximately 7×10^5 per second as of August 1966. This standard may be purchased only under the special licensing provisions of the Atomic Energy Act of 1954. Therefore a copy of the purchaser's AEC By-Product Material License must be on file at the Bureau.

These standards are issued for the accurate calibration of gamma-ray detectors and detector-spectrometer systems used in the measurement of cobalt-60 gamma-ray emission. Such calibration is needed because cobalt-60 is widely used in a variety of ways. For example, in medicine, cobalt-60-labeled vitamin B–12 is used to detect chronic myelogeneous leukemia, cobalt-60 tracers are used in the diagnosis of pernicious leukemia, and cobalt-60 sources are employed to treat cancer. In the petroleum industry cobalt-60 tracers are used in the control of mixing and sedimentation in mineral oil refining and processing plants. and cobalt-60-tagged steel balls are used in viscosity measurements. In transportation, several communication systems use cobalt-60 sources. One of these is used in railroad yards to keep track of cars; a small millicurie source is attached to the undercarriage of a car and is detected by a series of monitoring devices placed along the rails.

Reissued Radioactivity Standards

Two other radioactivity standards, NBS Standard Nos. 4944D and 4964B, have been reissued. NBS No. 4944D is an iodine-125, electron-capture solution standard, and NBS No. 4964B is a radium gamma-ray solution standard.

continued

REFERENCE *continued*

NBS Standard No. 4944D consists of iodine-125 and carrier in 5.044 ±0.011 grams of solution flame-sealed in a glass ampoule, and costs $53 per unit. The carrier solution contains 0.02 gram of Na_2SO_3 per liter, 0.02 gram of $LiOH \cdot H_2O$ per liter and 0.06 gram of KI per liter. The activity of the iodine-125 in disintegrations per gram of solution, at 1200 e.s.t. December 29, 1966, was $1.07^8 \times 10^5$ ±0.05 percent. Analysis of the gamma-ray spectrum indicated the presence of cesium-134 and cesium-137 each in the amount of 0.02 percent of this activity.

NBS Standard No. 4964B consists of radium-226 in approximately 5.2 grams of carrier solution in a flame-sealed glass ampoule. It is priced at $43 per unit. The carrier solution is 0.2 weight percent $BaCl_2 \cdot 2H_2O$ in a 5.8 weight percent solution of HCl. The nominal weight of radium in the ampoules as of June 1965 was 100 micrograms.

The radioactivity of the iodine standard is such that it may be ordered singly under the general licensing provisions of the Atomic Energy Act of 1954. Radium standards are not subject to these provisions.

[1] For a complete list of NBS standards, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards,** NBS Misc. Publ. 260, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents.

[2] **International Practical Temperature Scale of 1948, Text Revision** of 1960, NBS Mono. 37, Table 1, p. 2 (Sept. 8, 1961). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 10 cents.

FREQUENCY RANGE *continued*

Design Features

The new armature is a hollow sintered aluminum oxide (Al_2O_3) tube, 5½ inches long and integrally closed at one end. It is approximately 1⅞ inches in outside diameter and slightly less than 1½ inches in inside diameter. The closed end is ¾ inch thick and its surfaces are precisely normal to the armature axis. The accelerometer to be tested is screwed into a threaded hole in the center of the end, the calibrated reference pickup into the same hole from the inside of the tube.

The driving coil is wound in a shallow slot nearly an inch wide near the bottom of the armature and its turns embedded in epoxy cement. The coil leads run up inside the armature and emerge, like the reference pickup leads, from a hole near its top.

Most of the outside wall of the ceramic armature functions as a bearing surface, sliding in a stainless steel collar 3 inches high and having a row of air orifices ½ inch inside each end. Both bearing surfaces are finished to a smoothness of approximately 8 microinches, permitting a radial clearance of 0.0001 inch. The armature moves freely within the bearing when it is supplied with filtered air at a pressure of 50 pounds per square inch.

The armature is supported vertically by ¼-inch-diameter rubber tubes on three studs projecting from the armature. The tension on the tubes can be adjusted from their outer ends to position the armature as desired. Alternatively, vertical suspension can be accomplished by adjusting a direct current through the driving coil to lift the armature to the desired height.

An advantage of the new moving element is that no wires or attachments protrude from the ceramic cylinder below the leads and suspension studs at the top. Consequently, the armature can be withdrawn from the shaker when the rubber tubing is slid off the studs. This makes it easy to use armatures of alternative configuration and different standard pickups.

Use and Calibration

The pickup being calibrated is mounted on top of the moving element and its output compared with that of the reference accelerometer with which it is mounted back-to-back. The reference accelerometer can be calibrated by comparison of its output with that of a calibrated pickup mounted in the test position or by interferometric identification of certain vibration excursions.[4] It can also be calibrated, before installation, when mounted on the table of a calibration shaker.

The transverse motions of the shaker table are measured by mounting the test pickup on top of a tapped cube installed at the test position and comparing its output with those of calibrated pickups on each of the cube's four sides. The new shaker was found to accelerate test pickups weighing less than ½ pound to a level of 10 *g* with transverse acceleration within 1½ percent and distortion less than 1 percent. The shaker is capable of excursions as great as 0.7 inch. Its major resonance is at 25,000 Hz and its response is unqualifiedly acceptable below 5000 Hz. It can be used at frequencies up to 20 kHz if care is taken to avoid a few narrow frequency ranges in which transverse motion peaks.

[1] **An electrodynamic vibration standard with a ceramic moving element,** by T. Dimoff, J. Acous. Soc. Am. **40,** 671–676 (Sept. 1966).

[2] **Application of air bearings to an electrodynamic vibration standard,** by T. Dimoff and B. F. Payne, J. Res. NBS **67C,** 327–333 (Oct.–Dec. 1963), and **Improve electrodynamic vibrators with air bearings,** NBS Tech. News Bull. **48,** 178–179 (Oct. 1964).

[3] **Use of high-strength ceramic in vibration transducers,** E. Jones, J. Acous. Soc. Am. **36,** 1215–1216 (June 1964).

[4] **Photoelectronic measurement of vibratory displacement,** NBS Tech. News Bull. **47,** 9–10 (Jan. 1963), and **Modulated photoelectric measurement of vibration,** V. A. Schmidt, S. Edelman, E. R. Smith, and E. T. Pierce, J. Acous. Soc. Am. **34,** 455–458 (April 1962).

[5] Supported largely by Department of Defense agencies.

CONFERENCE & PUBLICATION *Briefs*

SECOND MATERIALS RESEARCH SYMPOSIUM ANNOUNCED

The Bureau has announced the Second Materials Research Symposium, "Molecular Dynamics and Structure of Solids" (Correlation of Various Spectroscopic and Diffraction Methods). This Symposium is sponsored by the NBS Institute for Materials Research and will be held at the Bureau's new site at Gaithersburg, Md., from October 16 to 19, 1967. General Chairman for the event is Carl O. Muehlhause, Assistant General Chairman is Vernon W. Myers, and Robert S. Carter is the Program Chairman.

The purpose of the Symposium is to encourage interdisciplinary cooperation by demonstrating the correlation of various techniques applied to the study of molecular dynamics and structure of solids. The Symposium will bring together experts on the principal methods of investigating these problems. Invited and contributed papers will review recent progress in these areas. It is hoped that the Symposium will stimulate among the participants a wider appreciation of the techniques outside their own specialties which could complement their work and lead to a more complete understanding of the materials of interest to them.

Development and improvement of measurement techniques for the study of materials by chemical and physical means is a responsibility of the NBS Institute for Materials Research. The Institute carries out this responsibility by serving as a focal point for development of measurement methodology and by encouraging the dissemination of relevant information. The Institute sponsors symposia to insure that information on materials, material research, and methods of obtaining such information are made available to the greatest possible extent. The First Materials Research Symposium, "Trace Characterization—Chemical and Physical" was held at NBS October 3–7, 1966.

The primary emphasis of the Second Materials Research Symposium will be placed on the correlation of structural and dynamic information obtained by various experimental techniques applied to the study of solids. The Symposium will include studies of inorganic solids (including hydrogen-bonded systems), organic crystals, polymers, and bio-molecules. The scope of the conference has been limited by omitting consideration of metals and alloys, simple ionic compounds such as alkali halides, and the effects of localized defects.

Invited lecturers will emphasize the complementary nature of infrared and n.m.r. spectroscopy, neutron inelastic scattering, and neutron and x-ray diffraction techniques as applied to the studies within the scope of the Symposium. Contributed papers, however, will not be limited to research using only these techniques; the presentation of pertinent results of other techniques such as thermodynamic measurements, dielectric measurements, and Mössbauer spectroscopy is encouraged. Papers demonstrating the correlation between several experimental techniques will be particularly welcome.

Structure studies will be most pertinent if they include some discussion of thermal motion and vibrational amplitudes, and dynamic studies should emphasize intermolecular vibrations and rotations in solids. Intramolecular modes will be included if they are strongly influenced by intermolecular coupling, as in hydrogen-bonded and polymeric materials.

The program will consist of morning and afternoon sessions equally divided between invited lectures and contributed papers. To allow ample time for discussion, a maximum time of 10 minutes will be allowed for oral presentation of contributed papers. As part of the 4-day Symposium, participants will be invited to tour the Bureau's new laboratory facilities including the 10 megawatt research reactor, the 100 MeV linear accelerator, and other laboratories of particular interest to the participants.

Those desiring to present papers should submit titles and abstracts of about 200 words to the Program Chairman before June 15, 1967. All individuals interested in receiving later announcements concerning the Symposium arrangements should address inquiries to:

Dr. Robert S. Carter, Program Chairman
2nd IMR Symposium
National Bureau of Standards
Washington, D.C. 20234

ASTM METRIC PRACTICE GUIDE

The Bureau, with the concurrence of the American Society for Testing and Materials, has recently published the second edition of the ASTM Metric Practice Guide as NBS Handbook 102.[1] This action was taken because of the Guide's usefulness to many segments of the American public.

The increased use of the International System of Units (SI), a modernized version of the metric system, both in the United States and abroad has created many problems for engineers, manufacturers, and people engaged in inter-

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A transparent salt was used to simulate opaque metals systems to determine molten metal flow patterns and velocity. W. S. Brower is positioning a horizontal boat containing a salt in the heating element for an experiment.

Thermal Convection

During Crystal Growth Studied

The solidification of molten metals is known to be affected by fluid motion. The effects of mechanical stirring on solidification structures are well documented. Recent research has shown that substantial fluid motion is already present in many melts in the form of thermal convection and that fluid motion of this type also affects the solidification structure in important ways.

In a recent study [1] by H. P. Utech, W. S. Brower, and J. G. Early of the NBS Institute for Materials Research, a technique was developed to observe directly the thermal convection currents in molten materials. In this study, supported by the Atomic Energy Commission and the Advanced Research Projects Agency, effort was directed toward determining flow patterns and velocities in horizontal boats of the type typically used to grow crystals.

Thermal convection has its origin in the density differences caused by the temperature gradients that are typically present during solidification. When the gradient is such that less dense (hotter) liquid is located above denser (cooler) liquid, no flow occurs. A stable situation such as this arises when crystals are grown by the Bridgman technique and thermal convection presents no problem. However, for any other crystal growing arrangement, for example, the Czochralski or horizontal-boat methods, more dense liquid will be located either above or beside less dense liquid and flow will occur. Such flow is called thermal convection.

Thermal convection during the growth of crystals can be important in a number of ways. For example, certain imperfections known as bands or striations frequently appear in doped semiconductor crystals grown from the melt. Such inhomogeneities are undesirable because they cause nonuniformities in the properties of the crystals. Recent work [2] has shown that these striations are caused by thermal convection.

Flow Patterns and Velocities

Prior to the present work, the most direct indication of the existence of thermal convection currents in molten metals was provided by temperature measurements. For example, the appearance of erratic temperature fluctuations was accepted as an indication of turbulence in the melt. However, temperature measurements provide little direct information on flow patterns and flow velocities. Also, conventional flow sensors are either too large for systems of this type or would themselves impede flow to the point of making measurements meaningless. In addition, the opacity of molten metals makes direct observation of flow impossible.

In the NBS study, the metal system was simulated with a transparent liquid in which flow was observed directly. Many transparent liquids such as water suggested themselves for such a study. However, it is important to use as simulant a liquid whose thermal diffusivity and viscosity are of the same order of magnitude as for metals. Sodium chloride comes quite close to fulfilling this requirement and since this salt is transparent, its flow can be observed directly.

To study direction and velocity of fluid motion, a graphite boat with inside dimensions of approximately 10 cm length by 1½ cm depth, containing molten sodium chloride was heated so that a temperature gradient of approximately 30 deg C per centimeter prevailed along its length. Thermal convection currents were clearly visible in the melt and were filmed with a 16 mm motion picture camera by W. P. Richardson of the NBS Photographic Services

Section. The following observations were made: (1) The molten salt flowed from the hot end toward the cold end along the top of the boat, and from the cold end toward the hot end along the bottom of the boat. At the cold end of the boat, there was downward flow. This is the circulation pattern expected from a knowledge of the density gradients in the system. (2) Vertical currents flowing upward and downward were evident along the entire length of the boat. These currents, which had not been anticipated, did not remain fixed in position for any length of time but shifted about erratically. (3) The flow was turbulent, as evidenced by the erratic paths followed by small foreign particles present in the melt. (4) When sensitive thermocouples were introduced into the molten salt, the same erratic temperature fluctuations typical of turbulent convection in metal systems were observed, confirming the validity of the salt as an analogue.

Thermocouple Probe Technique

In earlier studies on thermal convection in molten metal systems, it was found that a sequence of temperature fluctuations, recorded by a thermocouple inserted in the melt, was repeated a short time later by a second thermocouple located farther downstream. This finding provides a means for determining flow direction in a number of systems characterized by temperature fluctuations. Furthermore, it appeared that mean flow velocity could be computed by measuring the average time required for the fluctuations to travel the known distance.

To investigate the accuracy of this technique, two platinum vs platinum-rhodium thermocouples spaced 1.7 mm apart were positioned a few mm below the NaCl melt surface. The thermocouple outputs were monitored on a recorder while the flow was being filmed by the motion picture camera. The velocities measured from the film by following particular eddies and those calculated from the thermocouple signals agreed within a few percent.

To compare the flow patterns in a liquid metal with those of the salt, an open horizontal boat containing molten tin at a gradient sufficiently steep to cause temperature fluctuations was studied. The thermocouple technique was used to determine flow direction at various points in the boat. The study indicated a circulation pattern qualitatively similar to that observed in the NaCl motion pictures. Velocity determinations in tin using this technique have not yet been made.

The motion picture study of the sodium chloride thus has provided an insight into the convective flow of molten metals in horizontal boats. It has also verified the general applicability of dual thermocouple probes for determining flow velocities.

Magnetic Field Experiments

The principle of eddy current damping is well known. Motion of an electrical conductor through the lines of force of a magnetic field meets with a resistance proportional to the strength of the field. This technique is commonly used to damp the swings of the balance beam of an analytical balance. It has also been demonstrated to be effective in suppressing thermal convection in molten metals and semiconductors.[4]

Magnetic field solidification has already made it possible to grow semiconductor crystals of greatly improved uniformity. It should also be possible to alter solute distribution in crystals of metals and semiconductors by solidification in the presence of a magnetic field since this distribution is known to be affected by flow ahead of the liquid-solid interface. An attempt was made to verify this by unidirectionally solidifying two specimens of a tin–1 percent bismuth alloy. Solidification was induced by withdrawing the boat from the furnace at a rate of 1.5 cm/hr. The first specimen solidified in the absence of any applied field. The second specimen was subjected to a 0.35 tesla vertical d-c magnetic field.

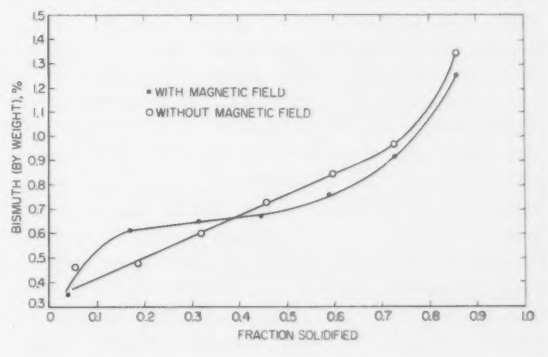
The solidified specimens were sectioned at approximately 2.5 cm intervals, then analyzed for bismuth by x-ray fluorescence. The results indicated that application of a magnetic field alters the solute distribution in the fashion expected.

[1] For further details, see **Thermal convection and crystal growth in horizontal boats**, by H. P. Utech, W. S. Brower, and J. G. Early, presented at the International Conference on Crystal Growth (Boston, June 1966), to be published in J. Phys. Chem. Solids.

[2] H. P. Utech and M. C. Flemings, J. Appl. Phys. **37**, 2021 (1966).

[3] D. R. Uhlmann, T. P. Seward III, and B. Chalmers, Trans. Met. Soc. AIME **236**, 527 (1966).

[4] H. P. Utech and M. C. Flemings, presented at the International Conference on Crystal Growth (Boston, June 1966), to be published in J. Phys. Chem. Solids.



The solute distribution of metal alloys can be altered by application of a magnetic field. These curves show the concentration of bismuth in two tin-bismuth alloy specimens after unidirectional solidification. For the specimen solidified with a magnetic field, the field strength was 0.35 tesla.

VARIABLE-TYPE ROTARY-VANE MICROWAVE ATTENUATORS CALIBRATED BY MODULATED SUBCARRIER TECHNIQUE

Accuracy Improved an Order of Magnitude

For a number of years, dating back to 1947, the Bureau has provided a service for the calibration of waveguide attenuators. The calibrations were performed by the Radio Standards Laboratory (RSL), now at Boulder, Colorado, and were first made on the popular X-band size, covering a nominal frequency range of 8.2 to 12.4 GHz. The basic measurement system originated elsewhere, [1] and RSL has added successive refinements that greatly improve its efficiency and accuracy. Known as the IF-substitution method, this system is adaptable to a wide variety of waveguide sizes and provides good accuracy over an attenuation range of 0 to approximately 50 dB; but it has the disadvantage of requiring two microwave signal sources. The systems that use the audiofrequency or d–c substitution methods have other disadvantages. Another system, incorporating the modulated subcarrier technique, combines the advantages of several methods and yields a high-level of measurement accuracy. It was developed by Schafer and Bowman of the Radio Standards Engineering Division of RSL in 1960 and was first reported at a London, England, meeting in 1961.[2]

At present, modulated subcarrier measurement systems are available at RSL for attenuation calibrations in WR90 waveguide (8.2 to 12.4 GHz) and in WR62 waveguide (12.4 to 18.0 GHz).

Improvements in equipment for the subcarrier technique were worked out over a period of several years. In the early stages of the effort, there were no commercially-produced variable waveguide attenuators with the scale resolution or precision of operation commensurate with the accuracy capability of this system. However, there were in-house needs for high resolution and accuracy, as in the calibration of an attenuator for a noise-temperature measurement system and in the calibration of new types of high-precision waveguide attenuators being developed by the Radio Standards Engineering Division.

Dean G. Melquist of the Microwave Calibration Services Section is responsible for a number of recent improvements in the technique. These include (1) an improved constant-amplitude, 1000-Hz phase shifter and associated electronic circuitry; (2) an improved null-detector amplifier that provides a greater signal-to-noise ratio and minimizes the adverse effects of harmonics; (3) the use of a coherent detector as the modulation frequency null detector, which provides a high degree of sensitivity in nulling the signals from the subcarrier channel and the reference standard channel; and (4) the use of an auxiliary microwave mixer that improves the overall stability of the system.

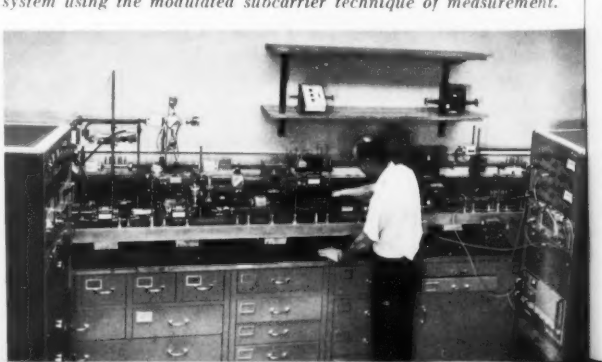
Outline of Technique

Briefly, the modulated subcarrier method of attenuation measurement functions as follows. The output of a microwave signal source is divided into two transmission channels, the energy in one channel (carrier) passing through an adjustable phase shift and amplitude control. Energy passing through the other channel (subcarrier) is amplitude modulated by a signal from a 1000-Hz signal source and then passed through the microwave attenuator being calibrated.

The energy in the subcarrier is fed to a microwave demodulator where it combines with the unmodulated energy from the carrier channel, allowing the demodulator to act as a linear power detector. The level of power in the subcarrier is maintained approximately 30 dB below the carrier in order that the modulation-frequency output from the microwave demodulator be proportional to the signal passing through the attenuator being calibrated. The circuitry permits accurate extraction of the 1000-Hz sideband power from the subcarrier.

The carrier signal is adjusted to be in phase with the subcarrier signal in the demodulator. The demodulated signal that contains the modulated sideband power is fed to a null detector circuit. A portion of the modulated (1000 Hz) subcarrier energy is fed to another microwave demodulator where it combines with a portion of the unmodulated carrier. This second demodulator also acts as a linear power detector. The second 1000-Hz demodulated signal passes through an adjustable phase-shift and amplitude control, and then through a voltage ratio transformer. This ratio transformer (also known as an in-

Dean Melquist adjusts tuning mechanism in preparation for calibrating a variable-type rotary-vane microwave attenuator with system using the modulated subcarrier technique of measurement.

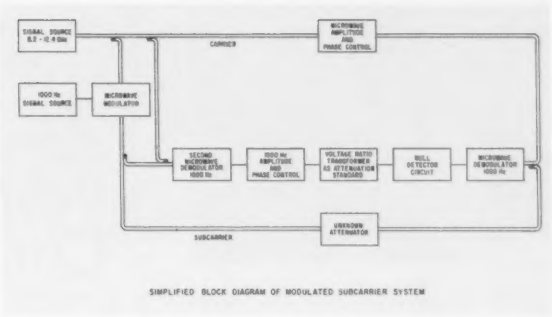


ductive voltage divider) is used as a precision attenuation standard. The emerging 1000-Hz energy is fed to the common null detector circuit.

The energy from the voltage ratio transformer can be very accurately controlled by the fine-scale settings of the transformer to precisely match the 1000-Hz sideband power that has passed through the attenuator under calibration. The null detector system can resolve differences in the two power levels to approximately 0.0005 dB. In performing a calibration, changes in attenuation level of the attenuator being calibrated are balanced by very accurately known changes of voltage level (or comparable power level) in the voltage ratio transformer.

This calibration system is capable of improving the accuracy of attenuation measurements in waveguide approximately tenfold over that of the IF-substitution or other commonly used methods. The capability of the present system for calibration of variable-type rotary-vane attenuators is an uncertainty of measurement no greater than 0.005 dB over a range of 0 to 15 dB.

Originally, the modulated subcarrier technique was developed as a means of reducing the cost of microwave attenuation measurement systems that incorporate the IF-substitution technique. It would eliminate the costly waveguide below-cutoff attenuation standard and the second microwave signal source required in the IF-substitution method. In practice, this expected economy was canceled by the cost of additional equipment required by the subcarrier method. However, the somewhat greater cost of performing a calibration is more than offset by the distinct advantage of a tenfold improvement in measurement accuracy; and additional calibration systems utilizing the modulated subcarrier technique are now being developed for other waveguide sizes.



SIMPLIFIED BLOCK DIAGRAM OF MODULATED SUBCARRIER SYSTEM

Simplied block diagram of modulated subcarrier system developed for calibrating waveguide attenuators.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT on the first day of a month. There will be no adjustment made on June 1, 1967. The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS–III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on June 1, 1967. The seconds pulses emitted from WWVB will be retarded 200 ms.*

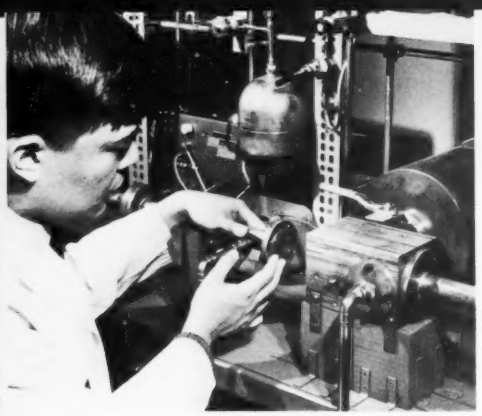
[1] A method of calibrating standard-signal generators and radio-frequency attenuators, by G. F. Gainsborough, J. Inst. Elec. Engrs. (London), **94**, Part 3, No. 29, 203–210 (May 1947).
[2] A modulated subcarrier technique of measuring microwave attenuation, by G. E. Schafer and R. R. Bowman, Proc. IEE, B–109, Supplement, 783–787 (May 1962).

CONF. & PUBLICATION BRIEFS *continued*

national trade. To facilitate the expression in SI units of quantities commonly expressed in United States customary units, ASTM established an *Ad Hoc* Committee on Metric Practice charged with the preparation of a Metric Practice Guide to provide the technical committees of ASTM with recommended procedures and factors for reduction to SI units.

This second edition, much larger and more complete than the first, represents concensus recommendations of the *Ad Hoc* Committee with which the Bureau has been happy to cooperate. Although in some minor ways ASTM practice does not conform to NBS practice, the document has been reproduced exactly as prepared for circulation within ASTM.

[1] NBS Handbook 102 is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 40 cents.



Dr. Tsang positions an acetate membrane to separate the high-pressure and low-pressure (foreground) sections of a shock tube. After the tube is pressurized, the membrane is ruptured by a solenoid-operated needle.

Shock Tube Produces Controlled Pyrolysis

The sequence and speeds of pyrolytic reactions of hydrocarbon gases are being determined, at the NBS Institute for Basic Standards, by heating the gases for brief instants by a shock wave. The speed at which a chemical bond is severed by pyrolysis at specific temperatures can be related to the energy of the bond. These reaction rates are found by Wing Tsang, of the Institute's physical chemistry laboratories, from concentrations of the sample and reference gases and their reaction products measured, after pyrolysis, by gas chromatography. The technique has yielded the reaction speeds for hexamethylethane, 2,2,3-trimethyl butane, 2,3-dimethyl butane, and neopentane,[1] and is now being applied to unsaturated hydrocarbons. The new knowledge being obtained is directed ultimately at helping select fuels and materials for furnaces and rocket motors—wherever high-temperature characteristics are important.

The thermal decomposition of a saturated hydrocarbon is an extremely complex kinetic process. Direct pyrolytic studies have not generally proved very fruitful, even from a qualitative point of view. Most of the available quantitative data have been obtained from studies of free radical kinetics, providing rate information on addition, abstraction, radical decomposition, and combination steps of reaction processes. However, such studies cannot provide any information about the initial steps of the thermal decomposition reaction; direct studies must be used for this purpose.

A single-pulse shock tube has been used at the Bureau during the past two years in direct studies of hydrocarbon pyrolysis. The procedure eliminates the possibility of heterogeneous reactions, drastically limits the length of homogeneous chains, and reduces the number of reactive species present in the system. As a result, the mechanisms and rates of the initial steps in the chain reactions of a large number of saturated hydrocarbons can now be determined.

At the present time studies on hexamethylethane, 2,2,3-trimethyl butane, 2,3-dimethyl butane, and neopentane (2,3-dimethyl propane) have been completed. In each of these cases the main initial reaction involves breaking the most highly substituted carbon-carbon bond. This is followed by extremely rapid decomposition of the newly formed alkyl radicals into olefins and hydrogen atoms.

The speed, k, of the bond-breaking reaction was found (for R=the gas constant and T=the absolute temperature) for several compounds:

a) $k(C_4H_9-C_4H_9 \rightarrow 2tC_4H_9\cdot) = 10^{16.3}\exp(-68{,}500/RT)\ \text{sec}^{-1}$

b) $k(C_4H_9-C_3H_7 \rightarrow t\cdot C_4H_9\cdot + iC_3H_7\cdot) = 10^{16.2}\exp(-73{,}000/RT)\ \text{sec}^{-1}$

c) $k(C_3H_7-C_3H_7 \rightarrow 2iC_3H_7\cdot) = 10^{16.1}\exp(-76{,}000/RT)\ \text{sec}^{-1}$

d) $k(C_4H_9-CH_3 \rightarrow t\cdot C_4H_9\cdot + CH_3-) = 10^{16.1}\exp(-78{,}200/RT)\ \text{sec}^{-1}.$

The values for these rates were used to estimate two additional reaction rates:

$k(CH_3-CH_3 \rightarrow 2CH_3\cdot) = 10^{14.9}\ \exp(-82{,}500/RT\ \text{sec}^{-1},$ and

$k(C_3H_7-CH_3 \rightarrow iC_3H_7\cdot + CH_3\cdot) = 10^{15.7}\exp(-79{,}500/RT)\ \text{sec}^{-1}.$

The pre-exponential factors are 2 to 3 orders of magnitude larger than "normal," although still surprisingly low to most kineticists. It is now necessary to revise commonly accepted views regarding the nature of these reactions; the activation energy offers the simplest way of determining the bond energy.

Equipment

The shock wave equipment is like that used in earlier studies at the Bureau.[2] Known concentrations in argon of both the gas being studied and the reference gas (cyclohexene) fill the shock tube, which is essentially a 2.5-cm (1-inch) brass tube 3.4 m (10.5 feet) long.

About half of the tube—the "low-pressure" section—

continued on p. 101

NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data.

Data and Information Center on Atomic Energy Levels

In recent years, rockets and orbiting satellites have given great impetus to the demand for more knowledge of laboratory spectra. For ground-based spectrographs, the ozone in the earth's atmosphere masks the spectral region short of 3000 Å. Now rocket solar spectra extend to the soft x-ray region, and other stellar spectra have been taken to 1200 Å. In the short-wave region, spectra of higher stages of ionization occur. Thus a whole new vista has opened to science. Demands for ionic spectra of abundant elements are incessant; they are needed to interpret the astrophysical observations. More than 15 years ago, Charlotte E. Moore, prepared an "Ultraviolet Multiplet Table" [1] in anticipation of these demands; however, this table does not suffice today.

With modern high-resolution equipment, improved solar and stellar spectra are being obtained in the visible and infrared. More faint lines are being observed than appear in the earlier records. This demands better observations of laboratory spectra—improved wavelengths, and sources that bring out faint lines not yet seen.

In 1946, the present NBS program was started on the critical compilation of atomic energy levels based on the analyses of optical spectra. At that time, W. F. Meggers pointed out that for the 92 chemical elements then known the theoretical number of optical spectra totaled 4656.[2]

Three volumes have been published to date.[3] They cover the periodic table except for the two groups of rare-earth elements, which will comprise Volume IV. The published material includes data for 482 spectra, but for many of these our knowledge is still incomplete.

Progress on Volume IV is slow but steady. Many of the rare-earth spectra are very complex. It has been necessary to reobserve them in order to obtain homogeneous line lists of spectra, carefully separated as to degrees of ionization. Some individual lists contain more than 15,000 lines for a given spectrum. One of the most complex, Ce I, has presented serious difficulties in the past. With the aid of digital computers and good observations, the complexities of the spectrum are being resolved in the NBS Spectroscopy Section.

As complete new monographs on separate spectra appear, the Data and Information Center on Atomic Energy Levels, under the direction of Charlotte E. Moore, is attempting to revise the earlier publications. A new series, entitled "Selected Tables of Atomic Spectra," contains revisions and extensions to both the energy-level and multiplet tables.[4] These are in great demand for the whole periodic table, but are appearing much too slowly to meet present needs.

The late W. F. Meggers contributed his valuable talent to this rare-earth program until the time of his death. Two of his monographs were then nearing completion, Yb I and Yb II. He planned these as "models" on the analyses of rare-earth spectra.

The Data and Information Center on Atomic Energy Levels is continuing Dr. Meggers work. The total number of known chemical elements is now 103. Artificially produced short-lived radioactive elements have been identified that extend the second group of rare-earth elements from Z=92 to Z=103. It is not expected that many spectra will be completely observed for these elements, but regularities have been found in the spectra of four: Np, Pu, Am, and Cm. Queries may be sent to the Center, National Bureau of Standards, Washington, D.C. 20234.

Joint ARPA-Office of Standard Reference Data Program

One major function of the Office of Standard Reference Data is to coordinate data projects to further specific interests of mission-oriented agencies. An example is the critical review program which the Office manages for the Advanced Research Projects Agency (ARPA).

The program relates to two phases of current NSRDS compilation work—the preparation of critical review monographs on selected topics in chemical kinetics, and the review, analysis, and tabulation of collision cross-section data for electrons, protons, atoms, atomic ions, small molecules, and small-molecule ions. Projects have

continued

been set up, including cooperative efforts with Oak Ridge National Laboratory and the Joint Institute for Laboratory Astrophysics (JILA), to meet high priority needs for data under the NSRDS. Under the ARPA contract the Office of Standard Reference Data has arranged for several review monographs on specific topics within this general area of special interest to ARPA. Thus, both the general goals of NSRDS and the mission needs of ARPA are being advanced.

Work in progress includes:

1. A review of kinetic data on oxygen, nitrogen, and oxides of nitrogen, by H. S. Johnston, University of California.
2. A theoretical review article on electronic excitation of atoms by electron impact, by B. Moiseiwitch, JILA.
3. A compilation of experimental data on elecron impact ionization, by L. E. Kieffer and G. H. Dunn, JILA.
4. A review of the theoretical aspects of item 3 above, by L. E. Kieffer, G. H. Dunn, and, at Queens University, Belfast, Ireland, M. R. H. Rudge.
5. A compilation and analysis of data, with theoretical considerations, of elastic and total electron scattering, by B. Bederson and L. E. Kieffer.
6. A state-of-the-art survey and resource analysis of quantum-mechanical computations of molecular orbitals.
7. A review of the role of the excited state in collision processes, by J. W. McGowan of General Atomic.

In addition, the Office of Standard Reference Data has independently sponsored several reviews on topics in gas-phase chemical kinetics that are of direct utility to ARPA studies. One of these reviews, a tabulation of bimolecular gas-phase reactions rate data, is in the publication process. Another, on unimolecular gas-phase decomposition reactions, is nearly completed.

Exploration of International Cooperation in Standard Reference Data Projects

For several years the National Bureau of Standards has supported a variety of research projects in India, Pakistan, and Israel where the Bureau has had authority to use P.L. 480 funds. Recently the NBS management decided to explore the possibility of concentrating the P.L. 480 program on three specific areas of prime interest to the Bureau: standard reference data, standard reference materials, and engineering standards. E. L. Brady, Chief of the Office of Standard Reference Data, was a member of a group which in January 1967 visited a number of institutions in the three countries to explore the possibilities of developing significant projects in these areas. In all three countries considerable interest was expressed in the concept and the program of the NSRDS. It is expected that significant projects of broad interest will be proposed for support in the area of standard reference data.

COSATI Panel on Information and Data Analysis Centers

The Committee on Scientific and Technical Information (COSATI) has set up a Panel on Information and Data Analysis Centers. E. L. Brady and S. A. Rossmassler of the Office of Standard Reference Data have been named Chairman and Executive Secretary, respectively, of the new unit.

According to the Panel's tentative charter, it will study and make recommendations on machinery for improvements in the management, operation, and utilization of information analysis and data centers in Federal agencies. Such centers differ from document centers in that they are primarily concerned with the substantive information and data *within* documents, rather than with the documents themselves.

High Pressure Data Center at Brigham Young University

The High Pressure Data Center at Brigham Young University is supported by the NBS Office of Standard Reference Data. Under the direction of H. Tracy Hall, the Center has recently completed its first year of operation. During this period a survey of the literature in the high pressure field has been the major effort. About 7,000 references to high pressure research believed to be comprehensive through April 1966 have been compiled. Recent contributions to the literature have been appearing at a rate in excess of 600 papers per year. A computer tape file on authors has been prepared and a computerized subject index will soon be completed. This index will include materials, properties, and methods. Critical evaluation of data on the pressure scale and compressibilities in the range 10–100 kilobars ($10–100 \times 10^8$ N/m^2) will begin during the current contract period.

Updated Bibliography of Electron Collision Data

The 1966 version of a "Bibliography of Low Energy Collision Cross Section Data" was recently published as NBS Miscellaneous Publication 289. This annual bibliography is cumulative, thus providing greater convenience for the user as well as more complete coverage. Three earlier editions were published and distributed through the Joint Institute for Laboratory Astrophysics (JILA) at the University of Colorado, as JILA Reports.

The text of the new bibliography has been put on tape, and later editions will be produced by computer-based combination of the existing material with each succeeding year's increment. This operation will shorten the time needed for manuscript preparation and for typesetting, and it is anticipated the 1967 edition will be available to the public by February of 1968.

As the bibliography grows, users may find that they need some sort of mechanized search-and-retrieval system; the computerized text will make such a system easy to develop.

For the present, 1600 references are categorized and indexed so that only a few minutes are required to find any particular paper, or all papers on any particular topic.

Forthcoming Standard Reference Data Publications

An inventory of forthcoming standard reference data publications gives an indication of the range and scale of activities now underway throughout the NSRDS. The inventory includes publications to be issued in the NSRDS series, other NBS compilations of data not within the NSRDS series, and non-data publications related to NSRDS activities. Publications to appear within calendar year 1967 are listed by category.

Technical Category	*No. of Publications*
Atomic & Molecular Properties	12
Thermodynamics & Transport Properties	9
Chemical Kinetics	4
Colloid & Surface Properties	2
Total	27

Each publication will be announced in NSRDS News as soon as it becomes available.

Survey and Analysis of Continuing Numerical Data Projects

It has become more and more apparent that publication of critical tables of standard reference data is one of the most important aspects of retrieving the results of scientific research from the literature. To aid in this work, the Office of Critical Tables of the National Academy of Sciences—National Research Council has just published a 1966 revision of Continuing Numerical Data Projects—A Survey and Analysis,[5] which was first published in 1961.

The new volume describes the operations and publications of more than 50 active projects engaged in the compilation of data. This is a significant increase over the content of the 1961 volume and reflects the growing involvement of the scientific community in the problem of data for science and technology. Most of the projects are in the United States, but some are in other countries, and a few result from international collaboration.

The total coverage of the projects described in this volume is not as great as that of the International Critical Tables (ICT). For most of the individual areas of the projects described, however, the coverage is in greater depth and more detail than the corresponding parts of the ICT.

The present volume will serve as the starting point for a more comprehensive worldwide survey of resources for evaluating and compiling numerical data. This worldwide survey will be started immediately by the Committee on Data for Science and Technology of the International Council of Scientific Unions through its Central Office which is at present located in Washington, D.C.[6]

[1] C. E. Moore, NBS Circ. 488: Section 1 (1950) and Section 2 (1952) issued in one volume for $1.25; Section 3 (1962) for 60 cents; Section 4 (1962) for 45 cents; Section 5 (1962) for 30 cents. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

[2] W. F. Meggers, J. Opt. Soc. Am. **36**, 442 (1946).

[3] C. E. Moore, NBS Circ. 467: Part I, $5.50 (1949); Part II, $3.00 (1952); and Part III, $4.00 (1958). Available from the Superintendent of Documents.

[4] C. E. Moore, NSRDS–NBS–3, Section 1, **Selected Tables of Atomic Spectra, Atomic Energy Levels, and Multiplet Tables, Si II, Si III, Si IV,** for 35 cents. Available from the Superintendent of Documents.

[5] Available from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418, for $5.00.

[6] **NSRDS News,** NBS Tech. News Bull. **51,** No. 1, 16–18 (Jan. 1967).

SHOCK TUBE *continued*

is permanently mounted with its open end in a brass junction block and with pressure transducers and a sample removal port near the other, closed end. The junction block contains the valve to the 36-liter "dump tank," tubing through which the gas mixture is introduced to the low-pressure end, and a seat on which a cellulose acetate membrane is placed to separate the low- and high-pressure ends. A flange of the high-pressure end when attached to the junction block clamps the membrane in position and mounts a solenoid, the plunger of which points a pin at the membrane.

The equipment is readied for use by installing the membrane, evacuating the low-pressure section and filling it with the desired concentrations of the sample and reference gases in argon, filling the dump tank with argon at the same total pressure, opening the valve between the dump and reaction cavities, and filling the high-pressure section with argon to the desired pressure.

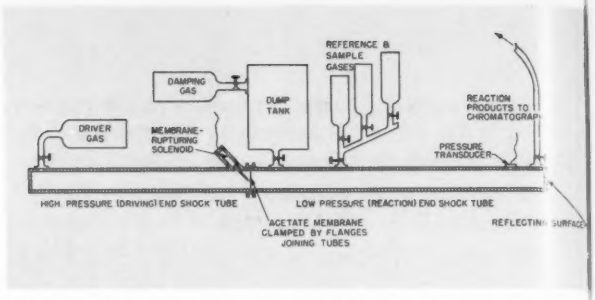
When the solenoid is energized the pin ruptures the membrane, allowing a shock wave to rush down the tube. The wave is only slightly attenuated by the dump tank and is reflected at the closed end of the tube. It whisks back toward the high-pressure end, and is almost completely damped in passing the dump tank orifice. Its duration is accurately known from the record of the transducer indications.

A sample of reacted gas is withdrawn from the closed end of the low-pressure tube immediately after the shock. The concentrations of original gases and reaction products for both the sample and the reference gas are determined by means of a gas chromatograph, using helium as the carrier gas. The reaction temperature is known from the

SHOCK TUBE *continued*

extent to which pyrolysis of the reference gas, unimolecular decyclization of cyclohexene to ethene and butene, has taken place.

The equipment and procedure used insure that the temperature will be great enough for the reactions of interest to occur only after the passage of the reflected shock wave from the low-pressure end. The speed at which this occurs minimizes wall effects and secondary reactions. The configuration of the tube and the speedy removal of the sample insure that the sample obtained will be unmixed with the driver gas.



Schematic of shock tube apparatus used in studying pyrolytic reactions of gases.

[1] Thermal decomposition of hexamethylethane, 2,2,3-trimethylbutane, and neopentane in a single-pulse shock tube, by Wing Tsang, J. Chem. Phys. **44**, 4283–4295 (June 1, 1966).

[2] Shock-tube kinetic studies using a reference standard, NBS Tech. News Bull. **48**, 101 (June 1964), and Comparative rate measurements with a single-pulse shock tube, by Wing Tsang, J. Chem. Phys. **40**, 1171–1172 (Feb. 1964).

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume **51**, No. 4, April 1967. 15 cents.

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A dual-load flow calorimeter for rf power measurement to 4 GHz. M. L. Crawford and P. A. Hudson.

Polymeric materials for dielectric reference specimens. A. H. Scott and J. R. Kinard, Jr.

The sensitivity of the Dicke radiometer. D. F. Wait.

Sensitivity of a correlation radiometer. J. J. Faris.

OTHER NBS PUBLICATIONS

Legibility of alphanumeric characters and other symbols. II. A reference handbook, D. Y. Cornog and F. C. Rose, NBS Misc. Publ. 262-2 (Feb. 10, 1967), $4.25.

Tables of molecular vibrational frequencies Part 1, T. Shimanouchi, NSRDS–NBS6 (Mar. 1, 1967), 40 cents.

Cast-iron radiators, R174–65 (Dec. 31, 1965), 10 cents. Supersedes R174–47.

Wire bar supports for reinforced concrete construction, PS7–66 (Aug. 1, 1966), 10 cents.

Procedures for precise determination of thermal radiation properties, November 1964 to October 1965, J. C. Richmond, G. J. Kneissl, D. L. Kelley, and F. J. Kelly, NBS Tech. Note 292 (Feb. 10, 1967), 50 cents.

PUBLICATIONS IN OTHER JOURNALS

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

CHEMISTRY

Bonding adhesives and paints to treated concrete, W. C. Wolfe, CSI Monograph 9M1, Construction Specifier, pp. 1–8 (Aug. 1966).

Characteristics of the laser probe for spectrochemical analysis, S. D. Rasberry, B. F. Scribner, and M. Margoshes, Proc. XII Intern. Spectroscopy Colloquium, Exeter, England, 1965, pp. 336–339 (Hilger and Watts, London, England, 1966).

Chemiluminescence of CH in the $O+C_2H_2$ reaction; Rotational relaxation and quenching, W. Brennen and T. Carrington, J. Chem. Phys. **46**, No. 1, 7–18 (Jan. 1, 1967).

Corrosion's many faces, S. Lichtenstein, Southern Eng. **85**, No. 1, 44–47 (Jan. 1967).

Dielectric constants of imperfect gases. III. Atomic gases, hydrogen, and nitrogen, R. H. Orcutt and R. H. Cole, J. Chem. Phys. **46**, No. 2, 697–702 (Jan. 15, 1967).

Ellipsometric-potentiostatic studies of iron passivity. I. Anodic film growth in slightly basic solutions, J. Kruger and J. P. Calvert, J. Electrochem. Soc. **114**, No. 1, 43–49 (Jan. 1967).

Formation of $NH(c^1\Phi)$ and $NH(A^3\Phi_i)$ in the vacuum-uv photolysis of HN_3, K. H. Welge, J. Chem. Phys. **45**, No. 11, 4373–4374 (Dec. 1, 1966).

Growth of calcite crystals, P. M. Gruzensky (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids D–3, pp. 365–367 (Pergamon Press Inc., New York, N.Y., 1967).

Growth of calcium molybdate crystals by a temperature-gradient zone-melting technique, H. S. Parker and W. S. Brower (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids E–12, pp. 489–491 (Pergamon Press Inc., New York, N.Y., 1967).

Introduction of the Acheson medalist, R. G. Bates, J. Electrochem. Soc. **113**, No. 12, 1–7 (Dec. 1966).

The crystal structure of twinned low-temperature lithium phosphate, C. Keffer, A. Mighell, F. Mauer, H. Swanson, and S. Block, Inorg. Chem. **6**, No. 1, 119–125 (Jan. 1967).

The ionization constant of deuterium oxide from 5 to 50°, A. K. Covington, R. A. Robinson, and R. G. Bates, J. Phys. Chem. **70**, 3820–3824 (1966).

The national standard reference data system, E. L. Brady, J. Chem. Doc. **7**, No. 1, 6–9 (Feb. 1967).

The optical and magnetic spectra of copper doped dichloro(1–10-phenanthroline) zinc, G. F. Kokoszka, C. W. Reimann, and H. C Allen, Jr., J. Phys. Chem. **71**, No. 1, 121–126 (Jan. 1967).

Time-dependent behavior of activated molecules. High pressure unimolecular rate constant and mass spectra, F. H. Mies and M. Krauss, J. Chem. Phys. **45**, No. 12, 4455–4468 (Dec. 15, 1966).

ENGINEERING AND INSTRUMENTATION

Approximate normal emissivity spectra in the infrared at elevated temperatures of single-crystal and polycrystalline calcium fluoride, W. B. Fussell and J. C. Geist, Appl. Opt. **6**, No. 1, 119–124 (Jan. 1967).

Electrodynamic vibration standard with a ceramic moving element, T. Dimoff, J. Acoust. Soc. Am. **40**, No. 3, 671–676 (Sept. 1966).

Interface kinetics and the stability of the shape of a solid sphere growing from the melt, S. R. Coriell and R. L. Parker (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids J–3, pp. 703–708 (Pergamon Press Inc., New York, N.Y., 1967).

Mechanical properties of chemically strengthened glasses at high temperatures, M. J. Kerper and T. G. Scuderi, J. Am. Ceram. Soc. **40**, No. 11, 613–618 (Nov. 1966).

On the solution of the Stefan problem for whisker growth, J. A. Simmons, H. Oser, and S. R. Coriell (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids C–8, pp. 255–264 (Pergamon Press Inc., New York, N.Y., 1967).

Procedures for precise determination of thermal radiation properties, J. C. Richmond, G. J. Kneissl, D. L. Kelley, and F. J. Kelly, Tech. Report AFML–TR–66–302 (Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, Aug. 1966).

Relation of fracture stress to the fracture pattern for glass rods of various diameters, M. J. Kerper and T. G. Scuderi, Am. Ceram. Soc. Bull. **45**, No. 12, 1065–1066 (Dec. 7, 1966).

The nucleation of Hg on W as observed by field-emission microscopy, S. C. Hardy (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids C–13, pp. 287–293 (Pergamon Press Inc., New York, N.Y., 1967).

Thermal convection and crystal growth in horizontal boats, flow pattern, velocity measurement, and solute distribution, H. P. Utech, W. S. Brower, and J. G. Early (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20–24, 1966), Crystal Growth, A Suppl. to J. Phys. Chem. Solids B–29, pp. 201–205 (Pergamon Press Inc., New York, N.Y., 1967).

Wind effect on pre-existing waves, G. Kulin, Proc. 1965 ASCE Conf. Coastal Engineering, Santa Barbara, California, October 1965, Chapt. 16, pp. 369–389 (American Society of Civil Engineers, 1966).

MATHEMATICS

A functional inequality, S. Haber, Am. Math. Mo. **73**, No. 10, 1103–1104 (Dec. 1966).

METROLOGY

Physiological optics at the National Bureau of Standards, D. B. Judd, Appl. Opt. **6**, No. 1, 13–26 (Jan. 1967).

The new tungsten-filament lamp standards of total irradiance, R. Stair, W. E. Schneider, and W. B. Fussell, Appl. Opt. **6**, No. 1, 101–105 (Jan. 1967).

The role of the National Bureau of Standards in the establishment of measurement capability at the state level, T. M. Stabler, Instr. Soc. Am. Preprint 16.1–3–66, pp. 1–3 (Oct. 1966).

PHYSICS

A vacuum ultraviolet flash photolysis apparatus, W. Braun, A. M. Bass, and A. E. Ledford, Jr., Appl. Opt. **6**, No. 1, 47–49 (Feb. 2, 1967).

Analysis of the α, β, and γ relaxations in polychlorotrifluoroethylene and polyethylene: dielectric and mechanical properties, J. D. Hoffman, G. Williams, and E. Passaglia, J. Polymer Sci. Pt. C, No. 14, 173–235 (1966).

Calculated heats of dilute solid solution among the alkali halides other than cesium salts, T. B. Douglas, J. Chem. Phys. **45**, No. 12, 4571–4585 (Dec. 15, 1966).

Concepts, terminology, and notation for optical modulation, C. S. McCamy, Photo. Sci. Eng. **10**, No. 6, 314–325 (Nov.–Dec. 1966).

Condensation of dry air on a liquid hydrogen cooled surface in the pressure range 10^{-5} to 10 torr (Knudsen number of 10^{-4} to 1), J. Hord, Cryogenics **6**, No. 5, 285–293 (Oct. 1966).

Elastic properties of NiTi as a function of temperature, S. Spinner and A. G. Rozner, J. Acoust. Soc. Am. **40**, No. 5, 1009–1015 (Nov. 1966).

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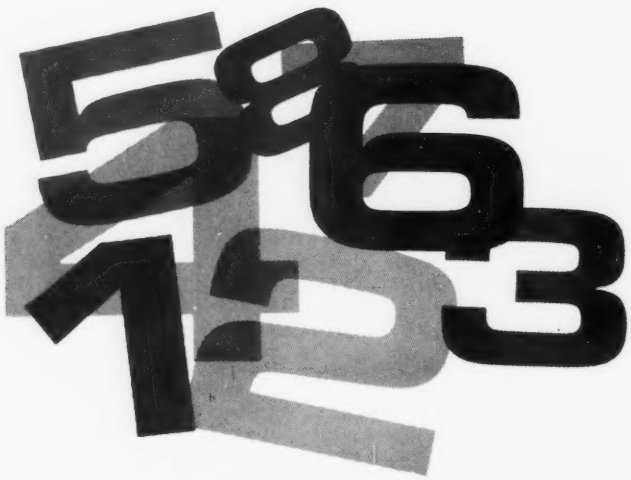

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